PATENT

IBM/209
Confirmation No. 3405

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	William Joseph Armstrong et al.	Art Unit:	2127
Serial No.:	09/939,235	Examiner:	Kenneth Tang
Filed:	August 24, 2001	Atty. Docket No.:	IBM/209
For:	YIELD ON MULTITHREADED PROCESSORS		

DECLARATION OF WILLIAM JOSEPH ARMSTRONG UNDER 37 CFR §1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, William Joseph Armstrong, hereby declare and state:

1. I am an inventor of the above-identified U.S. Patent Application.

2. Prior to July 7, 2001, I and my co-inventors, Chris Francois and Naresh Nayar, conceived of a concept of sharing resources on a multithreaded CPU capable of executing a plurality of threads.

3. In particular, we conceived of an apparatus, a program product, and a method of accommodating conventional yield calls within a multithreaded processor environment by coordinating yielding threads within the hypervisor.

4. Prior to July 7, 2001, I and my co-inventors submitted an invention disclosure form to our employer, International Business Machines Corporation, which described our improved apparatus, program products and methods. A copy of this form (with portions thereof redacted) is attached hereto as Exhibit A.

5. From the period prior to July 7, 2001, until the filing of the patent application on August 24, 2001, I and my co-inventors were diligent in constructively reducing our invention to practice. During this time period, we met with inside counsel at International Business Machines Corporation to explain our invention, participated in telephone calls with the outside counsel

assigned to prepare the patent application, provided supplemental materials to outside counsel to assist in preparing the patent application, reviewed a draft of the patent application prepared by outside counsel, supplied comments and suggested revisions to outside counsel, and reviewed and executed a final draft of the patent application.

6. The statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true; further, these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-referenced application or any patent issuing thereon.

Respectfully submitted,

2-11-2005
Date

William Joseph Armstrong

EXHIBIT

tabbies

A

Disclosure ROC8-2000-0643 ROC9-2000-0314-US1

Prepared for and/or by an IBM Attorney - IBM Confidential

Created By: Naresh Nayar
Last Modified By: Naresh Nayar

Required fields are marked with the asterisk (*) and must be filled in to complete the form.

***Title of disclosure (in English)**

Yield on Multithreaded Processors

Summary

Status	Under Evaluation
Processing Location	ROC
Functional Area	2U9 - SD - John Scales
Attorney/Patent Professional	Steve Roth/Rochester/IBM
IDT Team	Greg Andrews/Rochester/IBM; Eric Barsness/Rochester/IBM; Cary Bates/Rochester/IBM; Jennifer Bigus/Rochester/IBM; Brian Cragun/Rochester/IBM; Paul Day/Rochester/IBM; Rich Diedrich/Rochester/IBM; Thomas Gall/Rochester/IBM; Kevin Kathmann/Rochester/IBM; Gary Ricard/Rochester/IBM; Blair Wyman/Rochester/IBM; Steve Roth/Rochester/IBM
Submitted Date	
Owning Division	SD
Incentive Program	
Lab	
Technology Code	
PVT Score	No PVT score has been calculated.To calculate a PVT score, press the 'Calculate' button.

Inventors with Lotus Notes IDs

Inventors: Bill Armstrong/Rochester/IBM, Chris Francois/Rochester/IBM, Naresh Nayar/Rochester/IBM@IBMUS

Inventor Name	Inventor Serial	Div/Dept	Inventor Phone	Manager Name
Armstrong, William J. (Bill)	352105	7T/GY2A	553-0526	Scales, John W.
Francois, Chris	885087	7T/407A	000-0000	Woodbury, James E (Jim)
Nayar, Naresh	291248	7T/GY2A	553-4393	Scales, John W.

> denotes primary contact

Inventors without Lotus Notes IDs

IDT Selection

Select Functional Area

IDT Team:	Attorney/Patent Professional:

Greg Andrews/Rochester/IBM Eric Barsness/Rochester/IBM Cary Bates/Rochester/IBM Jennifer Bigus/Rochester/IBM Brian Cragun/Rochester/IBM Paul Day/Rochester/IBM Rich Diedrich/Rochester/IBM Thomas Gall/Rochester/IBM Kevin Kathmann/Rochester/IBM Gary Ricard/Rochester/IBM Blair Wyman/Rochester/IBM Steve Roth/Rochester/IBM	Steve Roth/Rochester/IBM

Response Due to IP&L :

***Main Idea**

1. Describe your invention, stating the problem solved (if appropriate), and indicating the advantages of using the invention.

On a system running multiple operating systems (each of them a *logical partition),* two or more of the operating systems may share a set of physical processors on the system. A key to getting good performance in this environment is that the operating system *yield* the physical processor to the hypervisor (the manager of the partitions on the machine) at key points in the operating system kernel. An example of such a yield point would be when the operating system enters the idle loop on a processor or is about to spin on a spinlock that is held by another processor. The yield allows the processor resources allocated to the partition to be utilized more efficiently (there are no wasted cycles in the idle loop or spinning on a lock).

On a multithreaded processor, each thread on the processor is an independent unit of execution. However, the threads share some of the resources on the processor. Examples of such resources are the TLB (translation lookaside buffer), and a single register on the processor that points to the hardware page table. The threads also have a shared priority scheme which dictates the allocation of processor cycles between threads. In the absence of additional hardware support, the implication is that all threads on the processor must execute in the same virtual address space. This further implies that all the threads on a processor must execute in the same partition or in the hypervisor.

Since the threads of the processor are independent units of execution, the problem that needs to be solved is that the yields executed by the threads need to be coordinated so that all the threads of a processor are either executing in the same partition or executing in the hypervisor.

2. How does the invention solve the problem or achieve an advantage,(a description of "the invention", including figures inline as appropriate)?

Yield on a non-multithreaded processor

At a yield point, the operating system calls yield(), which relinquishes the processor to the hypervisor. When the hypervisor gets control (via the yield() call), the state of the OS is saved, the processor then idles in the hypervisor until another partition (operating system) becomes ready-to-run. The partition is then dispatched on the processor and the operating system gets control again at the point where it yielded the processor.

Yield on a multithreaded processor

As mentioned above, the yield from all the threads on a processor has to be coordinated. In our approach, the coordination of the yield occurs in the hypervisor.

The OS calls yield() from a yield point from any thread on a processor.
1)The hypervisor gets control via the yield() call.
2) Instead of entering hypervisor idle state, the thread has to coordinate its yield() with other threads on the processor.
3)The thread records in shared storage that it is *ready to yield.* It then spins waiting for all threads on the processor to enter the *ready to yield* state.
4) When all threads on the processor record that they are *ready to yield,* all the threads notice that all other threads on the processor are now *ready to yield.*Each thread on the processor saves the state of the OS and enters the hypervisor idle state. When another partition (or the same) partition is ready to run, the partition is dispatched on all threads of the processor and the OS gets control in all threads at the point where it yielded the thread to the hypervisor.

When a thread is spinning in the *ready to yield* state, waiting for other threads to enter the ready to yield state, it continuously check to see whether the reason for its yield() has been satisfied (a timeout could have expired) or there is some work for it to do (the OS may be required to process an IO interrupt). In either of the two cases, the thread aborts its yield and returns. The OS gets control at the point where it yielded the processor.

3. If the same advantage or problem has been identified by others (inside/outside IBM), how have those others solved it and does your solution differ and why is it better?

To the best of our knowledge, this is the first design and implementation of yield for multithreaded processors. All other implementations of shared processors has occurred on S/390 and compatible machines. None of them has shipped with a multithreaded processor.

An alternative design approach (also not implemented anywhere to our knowledge) would be to have the operating system do the yield coordination and then have all threads make the yield() call simultaneously. That approach was considered by us, but rejected because it puts the complexity of the yield design in the operating system. Any operating system that wants to make efficient use of shared processors on multithreaded processors would have to be implement the complexity of a coordinated yield design for multithreaded machines.

The approach chosen by us allows the complexity to be buried in the hypervisor and does not require the operating system to make additional changes for yield on multithreaded machines.

4. If the invention is implemented in a product or prototype, include technical details, purpose, disclosure details to others and the date of that implementation.

The invention will ship as part of the Licensed Internal Code on the I series in V5R1M0.

***Critical Questions (Questions 1-8 must be answered)**

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For:	YIELD ON MULTITHREADED PROCESSORS		

DECLARATION OF CHRIS FRANCOIS UNDER 37 CFR §1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Chris Francois, hereby declare and state:

1. I am an inventor of the above-identified U.S. Patent Application.

2. Prior to July 7, 2001, I and my co-inventors, William Joseph Armstrong and Naresh Nayar, conceived of a concept of sharing resources on a multithreaded CPU capable of executing a plurality of threads.

3. In particular, we conceived of an apparatus, a program product, and a method of accommodating conventional yield calls within a multithreaded processor environment by coordinating yielding threads within the hypervisor.

4. Prior to July 7, 2001, I and my co-inventors submitted an invention disclosure form to our employer, International Business Machines Corporation, which described our improved apparatus, program products and methods. A copy of this form (with portions thereof redacted) is attached hereto as Exhibit A.

5. From the period prior to July 7, 2001, until the filing of the patent application on August 24, 2001, I and my co-inventors were diligent in constructively reducing our invention to practice. During this time period, we met with inside counsel at International Business Machines Corporation to explain our invention, participated in telephone calls with the outside counsel

2/11/2005

assigned to prepare the patent application, provided supplemental materials to outside counsel to assist in preparing the patent application, reviewed a draft of the patent application prepared by outside counsel, supplied comments and suggested revisions to outside counsel, and reviewed and executed a final draft of the patent application.

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Respectfully submitted,

2/11/2005
Date

Chris Francois

EXHIBIT

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Disclosure ROC8-2000-0643 ROC9-2000-0314-US1

Prepared for and/or by an IBM Attorney - IBM Confidential

Created By: Naresh Nayar
Last Modified By: Naresh Nayar

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***Title of disclosure (in English)**

Yield on Multithreaded Processors

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Functional Area	2U9 - SD - John Scales
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Submitted Date	
Owning Division	SD
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Technology Code	
PVT Score	No PVT score has been calculated.To calculate a PVT score, press the 'Calculate' button.

Inventors with Lotus Notes IDs

Inventors: Bill Armstrong/Rochester/IBM, Chris Francois/Rochester/IBM, Naresh Nayar/Rochester/IBM@IBMUS

Inventor Name	Inventor Serial	Div/Dept	Inventor Phone	Manager Name
Armstrong, William J. (Bill)	352105	7T/GY2A	553-0526	Scales, John W.
Francois, Chris	885087	7T/407A	000-0000	Woodbury, James E (Jim)
Nayar, Naresh	291248	7T/GY2A	553-4393	Scales, John W.

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Inventors without Lotus Notes IDs

IDT Selection

Select Functional Area

IDT Team:	Attorney/Patent Professional:

Greg Andrews/Rochester/IBM Eric Barsness/Rochester/IBM Cary Bates/Rochester/IBM Jennifer Bigus/Rochester/IBM Brian Cragun/Rochester/IBM Paul Day/Rochester/IBM Rich Diedrich/Rochester/IBM Thomas Gall/Rochester/IBM Kevin Kathmann/Rochester/IBM Gary Ricard/Rochester/IBM Blair Wyman/Rochester/IBM Steve Roth/Rochester/IBM	Steve Roth/Rochester/IBM

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***Main Idea**

1. Describe your invention, stating the problem solved (if appropriate), and indicating the advantages of using the invention.

On a system running multiple operating systems (each of them a *logical partition),* two or more of the operating systems may share a set of physical processors on the system. A key to getting good performance in this environment is that the operating system *yield* the physical processor to the hypervisor (the manager of the partitions on the machine) at key points in the operating system kernel. An example of such a yield point would be when the operating system enters the idle loop on a processor or is about to spin on a spinlock that is held by another processor. The yield allows the processor resources allocated to the partition to be utilized more efficiently (there are no wasted cycles in the idle loop or spinning on a lock).

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Since the threads of the processor are independent units of execution, the problem that needs to be solved is that the yields executed by the threads need to be coordinated so that all the threads of a processor are either executing in the same partition or executing in the hypervisor.

2. How does the invention solve the problem or achieve an advantage,(a description of "the invention", including figures inline as appropriate)?

Yield on a non-multithreaded processor

At a yield point, the operating system calls yield(), which relinquishes the processor to the hypervisor. When the hypervisor gets control (via the yield() call), the state of the OS is saved, the processor then idles in the hypervisor until another partition (operating system) becomes ready-to-run. The partition is then dispatched on the processor and the operating system gets control again at the point where it yielded the processor.

Yield on a multithreaded processor

As mentioned above, the yield from all the threads on a processor has to be coordinated. In our approach, the coordination of the yield occurs in the hypervisor.

The OS calls yield() from a yield point from any thread on a processor.
1)The hypervisor gets control via the yield() call.
2) Instead of entering hypervisor idle state, the thread has to coordinate its yield() with other threads on the processor.
3)The thread records in shared storage that it is *ready to yield.* It then spins waiting for all threads on the processor to enter the *ready to yield* state.
4) When all threads on the processor record that they are *ready to yield,* all the threads notice that all other threads on the processor are now *ready to yield.*Each thread on the processor saves the state of the OS and enters the hypervisor idle state. When another partition (or the same) partition is ready to run, the partition is dispatched on all threads of the processor and the OS gets control in all threads at the point where it yielded the thread to the hypervisor.

When a thread is spinning in the *ready to yield* state, waiting for other threads to enter the ready to yield state, it continuously check to see whether the reason for its yield() has been satisfied (a timeout could have expired) or there is some work for it to do (the OS may be required to process an IO interrupt). In either of the two cases, the thread aborts its yield and returns. The OS gets control at the point where it yielded the processor.

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***Critical Questions (Questions 1-8 must be answered)**

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Serial No.:	09/939,235	Examiner:	Kenneth Tang
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For:	YIELD ON MULTITHREADED PROCESSORS		

DECLARATION OF NARESH NAYAR UNDER 37 CFR §1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Naresh Nayar, hereby declare and state:

1. I am an inventor of the above-identified U.S. Patent Application.

2. Prior to July 7, 2001, I and my co-inventors, William Joseph Armstrong and Chris Francois, conceived of a concept of sharing resources on a multithreaded CPU capable of executing a plurality of threads.

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Respectfully submitted,

Naresh Nayar

02/11/05
Date

Naresh Nayar

EXHIBIT

tabbies

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Disclosure ROC8-2000-0643 ROC9-2000-0314-US1

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Created By: Naresh Nayar
Last Modified By: Naresh Nayar

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Technology Code	
PVT Score	No PVT score has been calculated.To calculate a PVT score, press the 'Calculate' button.

Inventors with Lotus Notes IDs

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The OS calls yield() from a yield point from any thread on a processor.
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3)The thread records in shared storage that it is *ready to yield.* It then spins waiting for all threads on the processor to enter the *ready to yield* state.
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DECLARATION OF DOUGLAS A. SCHOLER UNDER 37 CFR §1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Douglas A. Scholer, hereby declare and state:

1. I am an assistant of the attorney of record, Scott A. Stinebruner, for the above-identified U.S. patent application.

2. The activities noted below are submitted as evidence of the diligence of the Applicants during the time period prior to July 10, 2001 until the constructive reduction of practice of the invention on August 24, 2001, the filing date of the above-identified patent application. All of these acts took place in the United States.

3. By June 18, 2001, I had completed a first draft of a patent application based on a related disclosure to that for the above-identified application (which application was filed on August 24, 2001 and assigned Serial No. 09/939,232), and had received comments back from the inventor. The cover sheet from the facsimile conveying those comments is enclosed as Exhibit A.

4. By July 19, 2001, I had completed a second draft of the patent application based on the aforementioned '232 application. On that date , I faxed a copy of this second draft of the application to the inventors for their review. A copy of the fax cover sheet of July 19, 2001 is attached as Exhibit B.

5. By August 2, 2001 I had completed preparation of a first draft of the above-identified patent application, which was based in part on the aforementioned, '232 application. On that date, I faxed a copy of this draft to the inventors for their review. A copy of the fax cover sheet of August 2, 2001is enclosed as Exhibit C.

6. By August 10, 2001, I received comments from the inventors, which were incorporated into the patent application. A final draft of the patent application, including formal papers for signature, was forwarded to Steven W. Roth on August 13, 2001. A copy of the cover letter, dated August 13, 2001, is enclosed as Exhibit D.

7. The final draft of the patent application and the formal papers were received by Scott A. Stinebruner on August 24, 2001 and filed in the United States Patent and Trademark Office on August 24, 2001.

8. During the time period from prior to July 10, 2001 until August 24, 2001, continuous progress was made on constructively reducing the invention to practice, and as such, I was diligent in preparing and filing the above-identified patent application.

9. The statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true; further, these statements are made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-referenced application or any patent issuing thereon.

Respectfully submitted,

2/11/05
Date

Douglas A. Scholer
Reg. No. 52,197

IBM

Fax Cover

This is a confidential message, intended solely for the person to whom it is addressed. If you receive this message in error, please forward it to the correct person, or mail it back to us. Thank you.

To: SCOTT STINEBRUNER

Fax No. 513-421-7269

From: NARESH NAYAR

Fax No. 507-253-2870

Date/Time

Subject PATENT APPLICATION

Pages ——, including this one

EXHIBIT

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WOOD, HERRON & EVANS, L.L.P.

JOHN D. POFFENBERGER
BRUCE TITTEL
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PATENT, TRADEMARK, COPYRIGHT
AND UNFAIR COMPETITION LAW
AND RELATED LITIGATION

July 19, 2001

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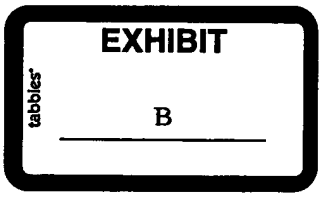

To: Naresh Nayar

Fax: 507-253-2870

From: Douglas A. Scholer

Re: Our File: IBM-182
New Application
YIELD ON MULTITHREADED PROCESSORS
Armstrong et al.
Client Reference:
ROC920000314US1

Pages: 25 (including cover sheet)

MESSAGE/COMMENTS

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August 2, 2001

FACSIMILE COVER SHEET

EXHIBIT
tabbies
C

To: Naresh Nayar

Fax: 507-253-2870

From: Douglas A. Scholer

Re: Our File: IBM-209
New Application
YIELD ON MULTITHREADED PROCESSORS
Armstrong et al.
Client Reference:
ROC920010252US1

Pages: 33 (including cover sheet)

MESSAGE/COMMENTS

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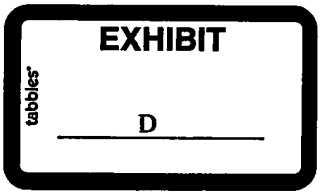

August 13, 2001

VIA FEDERAL EXPRESS

Steven W. Roth, Esq.
International Business Machines Corporation
Intellectual Property Law
Department 917
Building 006-1, 3605 Highway 52 North
Rochester, MN 55901-7829

Re: ROC920010252US1 SYSTEM FOR YIELDING TO A PROCESSOR
Our File: IBM/209
Client Ref: ROC9200120152US1

ACTION:	Return Application with Signed Documents
RESPOND BY:	As Soon As Possible

Dear Steve:

Please find enclosed a copy of the above-identified patent application for the inventors' review. Please have the inventors review this application in detail, keeping in mind that the application must fully describe the invention in such detail as to enable an individual of ordinary skill in the art to make and use the invention. In addition, the application must set forth what the inventors consider to be the "best mode" of practicing the various aspects of the invention. Also, please have the inventors review the independent claims to determine if there are any limitations that are not essential to define the basic inventive concepts disclosed in the application. If any changes or corrections need to be made to the application, please contact me immediately.

If the application is acceptable, please have the inventors sign and date the enclosed Declaration in blue ink, with the signatures matching the typed names exactly. In addition, the Assignment needs to be dated and signed on the same day as the Declaration.

After all the documents have been executed, please return the application with the signed documents to us for filing in the United States Patent and Trademark Office. In the meantime, if you have any questions or concerns, please do not hesitate to contact me.

Thank you again for allowing us to be of service to you in patenting this invention.

Very truly yours,

Scott A. Stinebruner

SAS/kw
Enclosures
K:\hwm\209\Roth App & Formal Docs Letter.wpd